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TITLE

ORIENTER FOR DRILLING TOOL ASSEMBLY

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ORIENTER FOR DRILLING TOOL ASSEMBLY

BACKGROUND OF THE INVENTION

Reference to Related Application

[0001] This application claims priority from U.S. Provisional Patent Application Serial Number 60/431,891 filed December 9, 2002.

Field

[0002] The disclosed invention generally relates to equipment for drilling boreholes beneath and generally parallel to the earth's surface; more particularly, the present invention pertains to equipment for providing power to and directing the path of a rotating drill bit. While the present invention is described herein with respect to shallow depth boreholes drilled for utility line installation, those of ordinary skill in the art will understand that the disclosed invention may be used in any type of coiled tubing drilling operation to include deep hole drilling for water, oil, or natural gas.

Background

[0003] In the installation of utility or transmission lines, the practice of drilling directionally controlled, generally horizontal, boreholes through the earth at generally shallow depths beneath the earth's surface has gained increasing acceptance. The combination of equipment to drill generally horizontal or directional boreholes is built around a downhole drilling motor apparatus, often called a mud motor, which is used for rotating the drill bit which cuts through soil and rock. While the disclosed orienter of the present invention is shown mounted to the downhole end of coiled tubing as shown in U.S. Patent No. 6,536,539 to the same assignee, it may also be used on the downhole end of a continuous non-rotating string of pipe segments.

[0004] To control the direction at which a generally horizontal borehole is drilled for utility line installation, some type of orienter is typically provided to direct the travel of the rotating drill bit along the desired path. Following the desired path may begin by requiring the rotating drill bit to first penetrate the earth's surface at a shallow angle, bore downwardly to a predetermined depth, then level out, then possibly direct the rotating drill bit to turn downward to move deeper, or possibly direct the rotating drill bit to turn to one side to avoid an obstacle, or to move along a more direct path toward a predetermined target, then finally, to turn upward to return back to the earth's surface.

[0005] In the art of drilling subterranean, substantially horizontal or directional boreholes with a rotating drill bit powered by a motor and advanced through the borehole by coiled tubing, there typically exists a need to position or direct a fixed bend or angle built into the downhole mounting for the rotating drill bit to facilitate directing the path of the borehole in something other than a straight line.

[0006] Various prior art drilling tool assemblies have been developed to cause a rotating drill bit to form a borehole whose path follows something other than a straight line. These prior art drilling tools utilize a variety of technologies to control the direction of the rotating drill bit and thus the path of the completed borehole. Some of the technologies for controlling the direction of the rotating drill bit include: a) pressure activated positioners, which operate independently to index the position of a downhole mud motor having a housing with a fixed bend, to a desired position; b) pressure activated tools which operate independently to create a "kick" or a temporary bend at a specific location, when activated by a predetermined signal; c) activated deflection shoes which independently operate to engage one side or face of the borehole, somewhere behind the cutting face of the rotating drill bit, to push the cutting tool face off to one side; and d)

rotary tools which either allow the drilling motor to be rotated to a desired position and then either locked into the desired position or which allow the drill motor to rotate constantly to provide a straight hole and then lock up on command when directional drilling is required. All of the devices which implement these technologies to form a borehole following something other than a straight line are commonly referred to as "orienters." In addition, prior art orienters typically require a separate source of power and control mechanism for redirecting the mounting apparatus for the rotating drill bit from a configuration which forms a bore hole following a straight line to a configuration which forms a bore hole following something other than a straight line, typically a shallow arc.

[0007] Generally, in subterranean shallow depth prior art coiled tubing drilling operations, the drilling tool assembly mounted to the end of a length of non-rotating coiled tubing includes: a rotating drill bit, preceded by a hydraulic motor assembly. The hydraulic motor assembly is typically housed in a long tube. Rotation of the motor is caused by the flow of drilling mud (typically called a "mud" motor). Above the mud motor, closer to the end of the coiled tubing, is a steering tool (or mechanism capable of tracking and reporting on the geometry of the path of the completed borehole). Above the steering tool and generally connected to the end of the coiled tubing is the orienter (a tool capable of changing the direction in which the rotating drill bit is pointed as it forms a subterranean shallow depth borehole). The coiled tubing connected to the orienter provides the linear force at the proximal end of the drilling tool assembly. It is this linear force which moves the drilling tool assembly through the borehole as the rotating drill bit cuts through the soil and rock at the drill face in contact with the rotating drill bit at the distal end of the drilling tool assembly.

[0008] The rotating drill bit is turned by the torque provided by the mud motor. The combination of the continuous rotary motion and the hardened projections on the end of the rotating drill bit enable the rotating drill bit to cut through soil and rock and thereby create a subterranean borehole. The mud motor produces the rotary power or torque needed to turn the drill bit by converting the energy from the flow of fluid or drilling mud, which is pumped through the mud motor, into rotary power or torque.

[0009] The steering tool, which is typically positioned behind or above the mud motor, provides signals which are used to track the path of the borehole, formed by a combination of straight and arcuate borehole segments.

[0010] The orienter portion of the drilling tool assembly is used to provide the necessary physical movements to position the entire drilling tool assembly to alter the path of the borehole by causing the drilling tool assembly to create a straight line segment or to create an arcuate segment.

[0011] In some prior art directional drilling systems, the drive shaft portion of the drilling motor is coupled to a swivel type joint or CV type joint at a point in the motor housing which includes a fixed bend. This construction allows for an oscillating rotation of the drive shaft in a conical fashion. Also, common in some prior art drilling tool assemblies, the orienter portion includes an array of thrust bearings and seals to properly displace and transmit the forces which determine the path of the borehole.

[0012] The geometry of the combination of the straight and arcuate segments at predetermined locations within the completed borehole is dictated, in part, by the bend in the mud motor housing. To create a straight segment of a borehole, the orienter facilitates either continuously rotating the drill and the bent portion of its mounting, or the orienter

periodically moves one or more components in the drilling tool assembly to form an arrangement which will produce a substantially straight borehole segment.

[0013] To create an arcuate segment of a borehole, the orienter typically does not allow the bent portion of the drill bit mounting to rotate, thereby enabling the fixed bend portion of the mud motor housing to create an arcuate segment of the borehole. Available orienters for use with drilling tool assemblies feature a multitude of designs and functions. The device disclosed in U.S. Patent No. 5,215,151, to Smith is illustrative of a drilling tool assembly including a fixed bend.

[0014] To monitor the position of the drilling tool assembly and the orientation of the rotating drill bit, a variety of different techniques have been utilized. Some systems utilize radio beacon transmitters located within the steering tool portion of the drilling tool assembly. This is known as a sonde housing. The radio signals from the transmitter in a sonde housing may be received either by using a walkover receiver or by using a wireline which follows the drilling tool assembly into the borehole. The radio signals provide necessary information about the position of the drilling tool assembly and the orientation of the rotating drill bit. Such rotating drill bit orientation information may include: clock face position, pitch, roll, yaw, and azimuth. With the information about the position of the drilling assembly and the orientation of the rotating drill bit, the operator may control the direction of the path of the borehole.

[0015] As the sophistication of coiled tubing drilling applications has progressed and new drilling tools are tested and operated, certain procedures have been found to be more conducive to drilling generally horizontal or directional boreholes with coiled tubing. As previously indicated, the drilling of boreholes for the installation of utility or

transmission lines typically includes causing the drilling tool assembly to first penetrate the ground surface at a shallow angle, then move to a predetermined depth, then traverse a generally horizontal predetermined path to travel under or around obstacles, and finally to move upwardly to exit the ground surface at a shallow angle some distance away. In such prior art drilling operations for the installation of utility lines, the entire drilling tool assembly (in some cases the rotating drill bit, the motor together with its housing, the steering tool, and the orienter can be as much as ten feet long) must completely exit the ground to be removed from the end of the coiled tubing. Simply because of the extended length of the drilling tool assembly, the process of removing the entire drilling tool assembly from the end of the coiled tubing can be quite cumbersome. Accordingly, it is desirable to develop an orienter for a drilling tool assembly that is simpler in construction, reduces the length of the drilling tool assembly, and reduces the power requirements without detracting from the functionality of the prior art orienters used in drilling tool assemblies.

[0016] There remains, therefore, in the art a need for a new system and method to orient a drilling tool assembly which simplifies the construction of the drilling tool assembly, shortens the length of the overall drilling tool assembly, and either minimizes the power required for orientation of the drilling tool assembly or eliminates the need for a separate power source to perform the orienting function.

SUMMARY

[0017] The disclosed orienter is simpler in construction, shorter than orienters found in the prior art, and reduces power requirements while maintaining the capabilities of prior art systems for drilling substantially horizontal or directional boreholes.

[0018] By changing the location of the orienter with respect to the other parts of a drilling tool assembly, the construction of the drilling tool assembly is simplified and the length of the drilling tool assembly is greatly reduced.

[0019] The disclosed preferred embodiment of the orienter is best described as a device operated by the torque produced by the drilling motor. The drive shaft which carries the torque produced by the drilling motor is enclosed in the internally driven, rotatable, external fixed bend housing of the orienter. When the internal clutch mechanism is engaged, the rotatable, external fixed bend housing of the orienter uses the torque from the drilling motor to rotate the external fixed bend housing, while at the same time causing the rotating drill bit to turn. This configuration creates a straight line section of the borehole. The rotatable, external, fixed bend housing is only disengaged from the drive shaft portion of the drilling motor when it is desired to create an arcuate section of the borehole. In this configuration, the external housing does not turn, and the housing is indexed or selectively rotated by the motor to a position in which the fixed bend directs the rotating drill bit along an arcuate path.

[0020] When the internal clutch mechanism is engaged, the rotatable, external fixed bend portion of the drilling motor housing receives rotational torque from the drive shaft portion of the drilling motor. By using the rotational torque from the drive shaft of the drilling motor, no additional separate drive mechanism is required to be placed into the drilling tool assembly for orienting the rotating drill bit within the borehole. An electrical, hydraulic, or mechanical signal is used to activate the internal clutch mechanism. This engagement of the clutch mechanism transmits the torque from the drive shaft portion of the drilling motor to the rotatable, external, fixed bend housing.

[0021] The upper section of the rotatable, external, fixed bend housing includes a speed reduction or torque conversion system. A clutch mechanism is attached to this internal speed reduction or torque conversion system. It is the speed reduction or torque conversion system which reduces the rotational speed of the drive shaft from the drill motor to an acceptable final output rpm for the external, rotatable housing.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0022] A better understanding of the orienter of the present invention may be had by reference to the drawing figures, wherein:

Figure 1 is a side elevational view of a system for drilling subterranean, shallow depth, substantially horizontal boreholes using coiled tubing;

Figure 2 is a side elevational schematic drawing of the arrangement of the key components in a drilling to assembly of the present invention, for drilling a subterranean borehole having an arcuate path;

Figure 3 is a side elevational schematic drawing of the oscillating action of the drilling tool assembly for drilling a borehole having a straight path;

Figure 4 is a side elevational schematic, in partial section, of the orienter of the present invention; and

Figure 5 is an alternate embodiment of the drilling tool assembly with the steering tool portion included in the orienter housing.

DESCRIPTION OF THE EMBODIMENTS

[0023] The orienter **10** of the present invention is attached to the drilling motor assembly **20** portion of a drilling tool assembly **100**. The motor assembly **20** portion is used primarily for turning the a rotating drill bit **130**. By repositioning the orienter assembly **10** of the present invention to a different location within the drilling tool assembly **100** than is found in prior art drilling tool assemblies, the construction of the drilling tool assembly is simplified and its overall length is reduced. This simplified construction and reduced length makes a drilling tool assembly **100** incorporating the orienter **10** of the present invention easier to use by eliminating the logistical issues and special job site planning considerations associated with more complex, longer length prior art drilling tool assemblies.

[0024] As may be seen in Figure 1, the orienter **10** of the present invention is used in a drilling tool assembly **100** which is mounted on the end **115** of a length of coiled tubing **110.** The coiled tubing **110** is typically stored on a mobile platform **200** at the earth's surface. An injector assembly **140** connected to the mobile platform **200** grasps the coiled tubing **110** and exerts linear force thereon to move it through a subterranean borehole.

[0025] As may be seen in Figure 2, the disclosed orienter **10** forms a part of a drilling tool assembly **100.** The drilling tool assembly **100** is designed and provided with the necessary hardware well known to those of ordinary skill in the art for mounting on the end of coiled tubing **110**. Beginning at the end **115** of the coiled tubing **110** which connects to the drilling tool assembly **100,** the drilling tool assembly **100** includes a steering tool assembly **120** for monitoring and tracking the position of the drilling tool assembly **100** in the borehole B as it is being drilled. Mounted next to the steering tool

assembly **120** is the drilling motor or mud motor assembly **20.** The drilling motor or mud motor assembly **20** is a hydraulic motor which produces rotational power or torque from the flow of drilling fluid or drilling mud through fluid flow passages within the motor assembly **20**. It is typically the motor assembly **20** which adds the greatest amount of length to the drilling tool assembly **100**.

[0026] According to the present invention, the orienter assembly **10** of the present invention is positioned in front of the drilling motor assembly **20**, just behind the rotating drill bit **130**. The orienter assembly **10** includes a rotatable housing **30** which may be divided into an upper section **32** and a lower section **34**. Finally, at the distal end **102** of the drilling tool assembly **100** is the rotating drill bit **130**. It is the rotating drill bit **130** which actually cuts through the soils and the rock to form the subterranean borehole B. Linear force transmitted to the drilling tool assembly **100** by the force placed on the coiled tubing **110** by the injector assembly **140**. The linear force moves the rotating drill bit **130** forward as the rotating drill bit **130** cuts through the soil and rock at the drill face at the end of the borehole.

[0027] In Figure 2 the rotatable housing **30** is held fast; that is, it does not rotate. Accordingly, the fixed bend **36** in the housing **30** of the orienter **10** causes the rotating drill bit **130** to form an arcuate segment of the borehole **B**. As shown in exaggerated manner in Figure 2, if the fixed bend **36** is in a substantially vertical plane, the drilling tool assembly **100** will form an arcuate segment of the borehole **B** which tracks upwardly to the earth's surface S, thereby allowing for removal of the drilling tool assembly **100** from the end **115** of the coiled tubing **110** after the drilling tool assembly **100** exits the borehole.

[0028] In contrast, the rotatable housing **30** shown in Figure 3 is not held fast or in a fixed position; instead, it is allowed to turn. The turning of the rotatable housing **30,** to include both the upper section **32**, the fixed bend **36**, and the lower portion **34,** with respect to the non-rotary housing **22** around the drilling motor **20,** enables the rotating drill bit **130** to cut a straight line segment of a large borehole. The transfer of torque from the drive shaft **24** portion of the drilling motor assembly **20** to the rotatable housing **30** causes the entire rotatable housing **30** to turn as shown in Figure 3.

[0029] In a macro sense, the housing **30** of the disclosed orienter **10** looks like an extension of the non-rotating housing **22** which surrounds the drill motor **20.** However, housing **30** is separate from housing **22**. This separation allows the external, rotatable housing **30** with a fixed bend **36** to rotate constantly at a minimal rpm while the drill motor assembly **20** causes the rotating drill bit **130** to move straight ahead with an oscillating action and thereby form a straight segment of the borehole **B′**, as shown in Figure 3. Disengagement of the mechanical connection between the external, rotatable housing **30** from the drive shaft **24** portion of the drill motor assembly **20** and the indexing of the housing **30** to the desired clock face position has the effect of placing the rotating drill bit **130** in a directional or steering mode as shown in Figure 2 because the fixed bend **36** in the external, rotatable housing **30** does not rotate. However, because the drive shaft **24** of the drilling motor **20** is still connected to the rotating drill bit **130** by a universal joint or flexible coupling **26,** the rotating drill bit continues to turn.

[0030] As shown in Figure 4, the necessary drive force or rotational torque which causes the external, rotatable housing **30** with a fixed bend **36** to turn is obtained from the drive shaft **22** of the drill motor assembly **20.** In the preferred embodiment, connection of

the external, rotatable housing **30** with a fixed bend **36** to the drive shaft **24** of the drill motor **20** is accomplished by the use of a mechanical clutch mechanism **40**.

[0031] The clutch mechanism **40** may be activated by a variety of different means to include an electrical, hydraulic, or mechanical signal. In the illustrated embodiment, the mechanical clutch mechanism **40** includes a first rotating tapered or wedge section **42** with an internal contact surface **44** which frictionally engages a second rotating tapered or wedge section **46** with an external contact surface **48**. The frictional contact between internal surface **44** and the external contact surface **48** is sufficient to transmit rotational torque from the drive shaft **22** to the internal gear assembly **60**. Those of ordinary skill in the art will understand that other types of mechanical clutch mechanisms or non-mechanical clutch mechanisms may be used without departing from the present invention. Such other clutch mechanisms may include electrical clutches and hydraulic clutches.

[0032] In the preferred embodiment, an internal gear assembly **60** within the rotatable housing **34** is used. The internal gear assembly **60** includes a plurality of externally toothed spur gears **62**. The rotation of the spur gears **62** causes rotation of the external housing **30** by engagement of a large internally-toothed ring gear **64** with the rotating spur gears **62**. The gear ratio between the spur gears **62** and the ring gear **64** provides for a reduction in speed and an increase in torque. The end result is a circular movement of the housing including the fixed bend **36** and the rotating drill bit **130** to drill a straight borehole through soil and rocks. Those of ordinary skill in the art will understand that while a simple speed reduction gear train has been shown in the preferred embodiment, other speed reducing or torque mechanisms may be used without departing

from the scope of the invention, to include but not limited to a hydraulic drive or a helical actuator.

[0033] To assure proper clock face position of the rotatable housing **30** with respect to the non-rotating housing **22** surrounding the motor assembly **20** or torque transfer, a set of radially spaced contact points or similar radial position indicating systems, well known to those of ordinary skill in the art, may be used to provide a signal representative of the clock position of the housing **30**. As the housing **30** is selectively rotated or indexed to a desired orientation by the motor **20**, a single contact closes a circuit at a location representative of the clock face position of the housing **30**. The signal is received at the surface using a wireless transmission or a wire line. Knowledge of the clock face position of the housing **30** enables the operator to assure that the fixed bend portion **36** of the orienter **10** is properly rotated or indexed to the desired orientation to create an arcuate segment of the borehole **B** which follows along a predetermined path.

Operation

[0034] A still better understanding of the orienter of the present invention may be had by an understanding of its method of operation.

[0035] The system and method of the present invention is part of a drilling tool assembly **100** which typically governs the operation and direction of a rotating drill bit **130**. As distinguished from prior art orienters, the orienter **10** is positioned next to the rotating drill bit **130**. The combination of the drill bit **130**, the orienter **10**, and the mud motor assembly **20** is located on the end **115** of coiled tubing **110**. Because the orienter **10** has been relocated to a position next to the rotating drill bit **130**, it is now in position where it can use the torque output of the mud motor assembly **20** rather than rely on a

separate source of torque or rotary power. Those of ordinary skill in the art will also understand that while the conventional location for the steering tool assembly **120** which provides an indication of tool **100** location behind the motor assembly may be used, a steering tool assembly **150** may also be located inside of the housing **30** or ahead of the mud motor assembly **20** as shown in Figure 5.

[0036] The orienter **10** of the present invention may be used with its own indicators to provide position information if necessary or desired. Specifically, the disclosed orienter **10** will be capable of including a radio beacon transmitter **50** for wireless or wireline reporting of the position and orientation of the rotatable housing **30**.

[0037] Also, as previously indicated, the disclosed system and method allows for the orienter **10** to be placed ahead of or in front of the mud motor assembly **20**. This arrangement simplifies construction and provides easier set up of drilling operations. In addition, this configuration enables the torque provided by the drilling motor **20** to both rotate the housing **30** including the fixed bend **36** for either drilling a straight line portion of the borehole **B′** or for rotating the housing to a desired clock face position for drilling an arcuate portion of the borehole **B**.

[0038] The preferred embodiment of the orienter **10** includes the use of a gear reduction system **60** driven by the output driveshaft **24** of the mud motor assembly **20** to both change the rotary speed and torque provided. The output driveshaft **24** of the mud motor assembly **20,** when engaged with the rotatable housing **30**, rotates the housing **30** that contains a fixed bend **36**. When desired, the gear reduction system **60** is disengaged from the output driveshaft **24** of the mud motor assembly **20** to cause the rotating drill bit **130** to create an arcuate borehole in a predetermined direction. The gear reduction

system **60** can then be re-engaged to provide continuous rotation of the housing **30**, thereby facilitating drilling a straight segment of the borehole as shown in Figure 3.

[0039] Observers of the entire system will see a large storage and spooling reel **108** containing a sufficient length of continuous coiled tubing **110** to be injected and retracted from the borehole as shown in Figure 1. The coiled tubing **110** is coupled to the storage and spooling reel **108**. The spooling reel **108** contains a fluid swivel at its center portion to allow fluids to be pumped through the coiled tubing **110**. An electrical wire, for communication of an electrical control signal or providing electrical power, may be inserted through the entire length of the coiled tubing **110** to provide access at the storage and spooling reel **108** for coupling to controls at the earth's surface using an electric swivel. The coiled tubing **110** is injected and retracted (pushed/pulled) by an injector assembly **140** that grasps the coiled tubing **110** and moves it in the desired direction.

[0040] The housing **22** containing the drill motor **20** itself does not contain a fixed bend section. Specifically, the drill motor assembly **20** is a straight mud motor known as a positive displacement motor or "monyo" style motor. The drill motor housing **22** abuts the leading end **115** of the coiled tubing **110** and is held in place by the coiled tubing **110** which resists the torque and tensile forces involved in the drilling process.

[0041] Typically, control of the orienter **10** requires communication of an electrical signal. This communication and any power required to actuate the clutch mechanism may be provided by an electrical wireline connection and pathway provided within the entire system. This pathway may either be fully inside the coiled tubing **110**

and drilling tool assembly **100** or maintained on the outside of the coiled tubing **110** and drilling tool assembly **100**.

[0042] Alternatively, wireless means may be used for control of the operation of the orienter **10**. When a wireless control system is used, a transmitter and receiver may be used to communicate with each other, providing instructions for when to engage and disengage (rotate or go steer) the orienter **10**. Such instruction can be implemented by installing a logic assembly in the orienter **10** that receives and sends data back and forth to a transmitter/receiver that is located in the coiled tubing **110** at the leading end of the tubing **105**, above the mud motor **20**.

[0043] Once the rotating drill bit **130** exits the ground, only the orienter portion **10** of the drilling tool assembly **100** need be pushed further out of the ground. If a back reaming tool powered by the mud motor is to be pulled back through the borehole, only the orienter **10** need be removed from the front of the mud motor assembly **20** to attach the back reamer.

[0044] Critical to the operation of the orienter **10** of the present invention is the amount of torque that is generated by the speed reduction or torque conversion system. In the preferred embodiment, the torque transferred by the internal gear reduction system **60** is determined by the design parameters of the gears **62, 64**. To minimize the effect of torque on the gears **62, 64**, two functions have been incorporated into the orienter **10**. The first function is a built-in slip in the frictional power transfer engagement of the clutch mechanism **40**. This built-in slip releases the drive shaft **24** at a given amount of excess torque to prevent damage. The second function is the basic design of the housing. Although it is imperative that the housing be robust enough to withstand the forces and

the conditions encountered when drilling a borehole, the housing has also been designed to minimize the amount of resistance against the sides of the borehole to prevent a potential lag -- which potential lag would be seen as increased torque load in the gear section.

[0045] While the present system and method has been disclosed according to the preferred embodiment of the invention, those of ordinary skill in the art will understand that other embodiments have also been enabled. Such other embodiments shall fall within the scope and meaning of the appended claims.